

TITLE OF THE INVENTION
VEHICLE-USE BEARING APPARATUS

BACKGROUND OF THE INVENTION

5 [Field of the invention]

The present invention relates to a vehicle-use bearing apparatus of a disk rotor in a disk brake apparatus, a hub unit to which wheels are attached, and the like. Particularly the invention relates to the vehicle-use bearing apparatus having a double row tapered roller bearing with vertex of contact angles outside of bearing.

[Description of the related art]

15 A double row tapered roller bearing with vertex of contact angles outside of bearing is generally used to receive large radial load, axial load and moment load which are applied from a vehicle body of large weight.

In a vehicle-use bearing apparatus having such a bearing, the bearing is externally fitted to an outer periphery of a hub wheel to which wheels are attached, and a shaft portion end of the hub wheel is deformed outwardly in a radial direction so as to be caulked to an outer end surface of one inner ring of the bearing.

In order to maintain rolling performance on rolling contact surfaces of inner and outer rings of the tapered roller, as shown in Fig. 7 which is an enlarged diagram of a main section on the caulked side of the bearing, the bearing is designed so that extended lines along rolling contact surfaces 23a and 21a of the inner ring 23 and the outer ring 21 with respect to a rotational axis L of a shaft portion of the hub wheel and an extended line along an outer peripheral surface of the tapered roller 22 meet at one point

Q on the rotational axis L of the hub wheel.

In this case, θ_1 is an angle of a raceway track of the inner ring 23 with respect to the rotational axis L, θ_2 is an angle of a raceway track of the outer ring 21 with respect to the rotational axis L, and θ_3 is an angle of an inner wall surface 23c of a cone back face rib 23b which is expanded outwardly in the radial direction on a large diameter side of the inner ring 23. 3 is a section which is caulked by the shaft end of the hub wheel.

As to the angles of the raceway tracks θ_1 and θ_2 and the angle of the inner wall surface θ_3 , the same design is applied to the other inner ring and outer ring, not shown, and these angles correspond to the angles of the raceway tracks of the other inner and outer rings and the angle of the inner wall surface of the cone back face rib.

In the prior art, when the shaft end of the hub wheel is bent and deformed outwardly in the radial direction so as to be caulked to the outer end surface of the inner ring 23, since the rolling contact surfaces 23a and 21a of the inner and outer rings and the cone back face rib 23b are elastically deformed, the angles of the raceway tracks θ_1 and θ_2 and the angle of the inner wall surface 23c, θ_3 , which are regulated to originally required angles are occasionally changed.

In this case, a contact state of the tapered roller with the rolling contact surfaces and the inner wall surface becomes unstable, namely, a life of the bearing apparatus is influenced.

SUMMARY OF THE INVENTION

Therefore, it is a main object of the present invention to provide a vehicle-use bearing apparatus in which after

a shaft end of a hub wheel is caulked, forms of raceway tracks of inner and outer rings are optimized and a life of a bearing can be improved.

Another object, characteristics and advantages of the present invention will become clear by the following description.

In short, the present invention includes: a hub wheel to which a wheel is attached; and a double row tapered roller bearing with vertex of contact angles outside of bearing to be attached to an outer periphery of said hub wheel, and is designed so that a shaft end of the hub wheel is deformed outwardly in a radial direction so as to be caulked to an outer end surface of an inner ring of the tapered roller bearing, and the tapered roller bearing has an inner ring and an outer ring whose rolling contact surfaces are tapered and a tapered roller which is arranged between the rolling contact surface of the inner ring and the rolling contact surface of the outer ring, and a form of a raceway track of at least one of the inner and outer rings is designed so as to satisfy a condition that a predetermined form is secured in a state that the raceway track is elastically deformed by the caulking.

In this design, even if the shaft end of the hub wheel is bent and deformed outwardly in the radial direction to the outer end surface of the inner ring so as to be caulked, an angle of the raceway tracks of the inner and outer rings after caulking, for example, an angle of the rolling contact surfaces of the inner and outer rings can be set to a prescribed angle which is originally required. As a result, in this design, satisfactory rolling performance of the tapered roller can be secured, and these raceway tracks and raceway tracks of the other inner and outer rings can be

balanced. A predetermined life of the bearing apparatus after the caulking can be secured.

Preferably in the present invention, the condition is such that the form of the raceway track of at least one of
5 the inner and outer rings before caulking is set so that an extended line along one of the rolling contact surface and an extended line along an outer peripheral surface of the tapered roller meet at a rotational axis of the hub wheel after the caulking.

10 Preferably in the present invention, the condition is such that the forms of the raceway tracks of the inner and outer rings before the caulking are set so that extended lines along the rolling contact surfaces of the outer and inner rings and an extended line along an outer peripheral surface
15 of the tapered roller meet at a rotational axis of the hub wheel.

Preferably in the present invention, the condition is such that an angle of the rolling contact surface of the inner ring before the caulking is set to an angle obtained by
20 subtracting a fluctuation angle of the rolling contact surface due to the caulking from an angle of the rolling contact surface where the raceway track of the inner ring secures a required form.

Preferably in the present invention, the condition is
25 such that an angle of the rolling contact surface of the outer ring before the caulking is set to an angle obtained by adding a fluctuation angle of the rolling contact surface of the inner ring due to the caulking to an angle of the rolling contact surface where the raceway track of the outer ring
30 secures a required form.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects as well as advantages of the invention will become clear by the following description of preferred embodiments of the invention with reference to the accompanying drawings, wherein:

5 Fig. 1 is a side view of a longitudinal section of a vehicle-use bearing apparatus according to a preferable embodiment of the present invention;

 Fig. 2 is an enlarged diagram of a main section of Fig. 1;

10 Fig. 3 is a function explanatory diagram of the vehicle-use bearing apparatus of Fig. 1;

 Fig. 4 is an another function explanatory diagram of the vehicle-use bearing apparatus of Fig. 1;

15 Fig. 5 is a side diagram of a longitudinal section of the vehicle-use bearing apparatus according to another embodiment of the present invention;

 Fig. 6 is a side view of a longitudinal section of the vehicle-use bearing apparatus according to still another embodiment of the present invention; and

20 Fig. 7 is an enlarged cross section of a main section of a prior vehicle-use bearing apparatus.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

25 There will be explained below a vehicle-use bearing apparatus of the present invention which is applied to an automobile. This bearing apparatus is not limited to an automobile use, and it can be applied similarly to another vehicles such as railway vehicle.

30 With reference to Figs. 1 through 3, a symbol A shows a whole vehicle-use bearing apparatus which is used on a driven wheel side of an automobile.

 A hub wheel 1 has an annular flange 11 which faces

outwardly in a radial direction, to which a wheel, not shown,
is attached, on a vehicle outer side. A double row tapered
roller bearing with vertex of contact angles outside of
bearing 2 is externally fitted to an outer periphery of a
5 vehicle inner side of the hub wheel 1.

This bearing 2 includes a single outer ring 21 having
two-row rolling contact surfaces 21a and 21b adjacently to
each other in an axial direction, a plurality of tapered
rollers 22 which are arranged on the two-row rolling contact
10 surfaces 21a and 21b, and an inner ring 23 which has a single
rolling contact surface 23a which is paired with the rolling
contact surface 21a on the vehicle inner side of the outer
ring 21 and is fitted to an outer peripheral surface of the
hub wheel 1. Moreover, the bearing 2 is constituted so that
15 a required area of the outer peripheral surface of the hub
wheel 1 is utilized as a rolling contact surface 12a which
is paired with the rolling contact surface 21b on the vehicle
outer side of the outer ring 21. 25 is a cage.

The rolling contact surface 21a on the vehicle inner
20 side of the outer ring 21 is tapered such that its diameter
is larger towards a shaft end of the vehicle inner side of
the hub wheel 1. The rolling contact surface 21b of the
vehicle outer side is tapered such that its diameter is larger
towards a shaft end of the vehicle outer side of the hub wheel
25 1.

The rolling contact surface 23a of the inner ring 23
is tapered such that its diameter is larger towards the shaft
end of the vehicle inner side of the hub wheel 1. A cone
back face rib 23b which is expanded outwardly in the radial
30 direction is formed on the large diameter side of the tapered
rolling contact surface 23a.

A raceway track of the inner ring 23 is composed of

the tapered rolling contact surface 23a and an inner wall surface 23c of the cone back face rib 23b.

The vehicle inner side of the hub wheel 1 has a hollow form, and the shaft end of the vehicle inner side is bent
5 outwardly in the radial direction and is caulked to an outer end surface of the inner ring 23 of the bearing 2 so as to be a caulked portion 3.

A radially outward flange 24 is provided on an outer periphery of the outer ring 21. The outer ring 21 is mounted
10 to an axle case or the like, not shown, via the flange 24 so as not to be rotated.

The raceway tracks of the inner ring 23 and the outer ring 21 in the bearing 2 are designed so as to satisfy a condition which secures a predetermined form in a state that
15 the raceway tracks are elastically deformed by caulking.

This design will be explained below with reference to Fig. 3. Fig. 3 shows an exaggerated state for easy understanding.

In short, the inner ring 23, the outer ring 21 and the
20 inner wall surface 23c are designed so that the raceway tracks of the inner ring 23, the outer ring 21 and the inner wall surface 23c of the cone back face rib 23b has predetermined forms (forms shown by virtual lines) which are different from the forms shown by continuous lines before caulking in order
25 to allow elastic deformation due to caulking for the originally required forms (forms shown by the continuous lines).

In order to obtain this design form, a change amount according to a caulking load for each dimension of the
30 vehicle-use bearing apparatus is checked by experiment, and the design is obtained experimentally so as to be set.

The details will be explained below. Firstly 01a, 02a

and θ_{3a} are angles of the shaft end of the hub wheel 1 before caulking, and the raceway tracks of the inner ring 23 and the outer ring 21 are designed so as to obtain forms based on these angles before caulking.

5 In addition, θ_1 , θ_2 and θ_3 are angles after caulking, and angles which obtain the originally required forms of the raceway tracks of the inner ring 23 and the outer ring 21.

10 Here, θ_{1a} and θ_1 are angles of the rolling contact surface of the inner ring 23 with respect to a rotational axis L of the hub wheel 1, θ_{2a} and θ_2 are angles of the rolling contact surface of the outer ring 21 with respect to the rotational axis L of the hub wheel 1, and θ_{3a} and θ_3 are tilt angles of the inner wall surface 23c of the cone back face rib 23b with respect to the radial direction.

15 As a result of the experiment, the angle of the rolling contact surface of the inner ring 23 before caulking becomes larger after caulking, namely, it is changed from θ_{1a} to θ_1 , and the angle of the rolling contact surface of the outer ring 21 before caulking does not change after caulking (θ_{2a}
20 = θ_2).

 The tilt angle of the inner wall surface 23c of the cone back face rib 23 before caulking becomes smaller after caulking, namely, it is changed from θ_{3a} to θ_3 .

25 The tilt angle of the inner wall surface 23c of the cone back face rib 23 becomes smaller due to calking, namely, it is changed from θ_{3a} to θ_3 because the angle of the rolling contact surface of the inner ring 23, θ_{1a} , before calking becomes larger due to caulking and becomes θ_1 after caulking, and the angle of the rolling contact surface of the outer
30 ring 21, θ_{2a} does not change before and after caulking and thus the tapered rollers 22 pushes the cone back face rib 23 due to a wedge effect.

Fluctuating angles of the inner ring 23, the outer ring 21 and the inner wall surface 23c which fluctuate due to a caulking load with respect to the outer end surface of the inner ring 23 due to caulking are $\Delta\theta_1$, $\Delta\theta_2$ and $\Delta\theta_3$.

5 The angle of the rolling contact surface of the inner ring 23 before caulking θ_{1a} is set to an angle θ_{1a} ($= \theta_1 - \Delta\theta_1$) obtained by subtracting a fluctuation angle of the rolling contact surface $\Delta\theta_1$ from the angle of the rolling contact surface θ_1 where the raceway track of the inner ring
10 23 secures the originally required form.

The tilt angle θ_{3a} of the inner wall surface 23c of the cone back face rib 23 before caulking is set to an angle θ_{3a} ($= \theta_3 + \Delta\theta_3$) obtained by adding a fluctuation tilt angle $\Delta\theta_3$ due to caulking to the tilt angle θ_3 where the inner wall
15 surface 23c secures the originally required form.

With the above settings, the angle of the rolling contact surface of the inner ring 23 is changed from θ_{1a} before caulking into θ_1 after caulking, and the tilt angle of the inner wall surface 23c is changed from θ_{3a} before caulking
20 into θ_3 after caulking.

As a result, as shown in Fig. 3, after caulking, extended lines L1 and L2 along the rolling contact surfaces of the inner ring 23 and the outer ring 21 and an extended line along the outer peripheral surface of the tapered
25 rollers 22 with respect to the rotational axis L of the hub wheel 1 meet at one point Q on the rotational axis L. The forms of the rolling contact surfaces of the inner ring 23 and the outer ring 21 and the inner wall surface 23c are optimized, and their contact states with the tapered rollers
30 22 become stable so that the life of the bearing is improved.

Here, in the case of the above embodiment, elastic deformation due to caulking is allowed for the originally

required forms (forms shown by continuous lines) of the angle of the rolling contact surface, θ_{1a} , of the inner ring 23 and the tilt angle θ_{3a} of the inner wall surface 23c, and thus the angle of the rolling contact surface, θ_{1a} , of the inner ring 23 and the tilt angle θ_{3a} of the inner wall surface 23c are designed so as to have predetermined forms (shown by virtual lines) different from the forms shown by continuous lines before caulking. However, the raceway track of the outer ring 21 can be designed in such a manner.

10 In addition, in the case where the raceway track of the outer ring 21 is designed, as shown in Fig. 4, the angle of the rolling contact surface of the inner ring 23 is fixed to θ_1 , and the angle of the rolling contact surface of the outer ring 21 is premeditatedly set to an angle $\theta_{2a}' (= \theta_2 + \Delta\theta_1)$ obtained by adding a fluctuation angle of the rolling contact surface of the inner ring 23, $\Delta\theta_1$, to the angle of the rolling contact surface, θ_2 , where the raceway track of the outer ring 21 secures the originally required form. As a result, deformation due to the angle of the rolling contact surface of the inner ring 23 can be absorbed by the side of the outer ring 21.

In addition, since $\Delta\theta_3$ is obtained because $\theta_{2a} = \theta_2$ due to $\Delta\theta_1$, $\Delta\theta_3 \doteq 0$ due to θ_{2a}' .

25 Further, the above design can be applied to the forms of the raceway tracks of both the inner ring 23 and the outer ring 21. In this case, a fluctuation angle of the rolling contact surface of the inner ring 23, $\Delta\theta_1$, due to caulking is allocated to the angles of the rolling contact surfaces of the inner ring 23 and the outer ring 21.

30 Here, in the above embodiment, one of the two inner rings in the tapered roller bearing 2 is the inner ring 23 itself, but as for the other inner ring, the required area

of the outer peripheral surface of the hub wheel 1 is utilized as the rolling contact surface 12a which is paired with the rolling contact surface 21a on the vehicle outer side of the outer ring 21.

5 On the contrary, the present invention can be applied to a structure that both the inner rings 23 in the tapered roller bearing 2 shown in Fig. 5 are provided to the vehicle outer side and the vehicle inner side.

 Namely, also in the case of the vehicle-use bearing
10 apparatus of Fig. 5, the raceway track of at least one of the outer ring 21 and the vehicle inner side inner ring 23 in the tapered bearing 2 is desired so as to satisfy a condition that a predetermined form is secured in a state that the raceway track is elastically deformed by the
15 caulking. This condition can be also determined similarly to the embodiments in Figs. 1 through 3.

 Here, the vehicle-use bearing apparatus in the above embodiment is on the driven wheel side of the vehicle, but may be on the driving wheel side as shown in Fig. 6.

20 The vehicle-use bearing apparatus shown in Fig. 6 has an equal velocity joint 3 in addition to the hub wheel 1 and the double row tapered roller bearing with vertex of contact angles outside of bearing 2.

 The hub wheel 1 has a center hole 1a.

25 The equal velocity joint 3 is called, for example, as a well-know Zeppa type (bar field type) equal velocity joint, and it is composed of an outer ring 31, an inner ring 32, a ball 33, a cage 34 and the like.

 The outer ring 31 is composed of a bowl type drum
30 section 35 which houses the inner ring 32, ball 33, the cage 34 and the like, and a shaft section 36 which is connected integrally with a small diameter side of the bowl type drum

section 35.

One end of a shaft 7 (driving shaft) is spline-fitted into the inner ring 32 and is fixed by a retaining ring (symbol not shown) so as not to slip off, and the other end of the shaft 7 is attached to a vehicle differential device via another equal velocity joint, not shown.

The double row tapered roller bearing with vertex of contact angles outside of bearing 2 is attached to the outer peripheral surface of the hub wheel 1, and the equal velocity joint 3 is attached to the center hole 1a of the hub wheel 1 so as to be rotatable integrally with the hub wheel 1 in a state that it is close to the double row tapered roller bearing with vertex of contact angles outside of bearing 2.

In addition, a bolt 13 for fixing a disc rotor and a wheel (not shown) of a disc brake apparatus is attached to some places on the circumference of the flange 11 in a penetrant state.

In such a vehicle-use hub unit, a rotational power of the shaft 7 is transmitted to the wheel (not shown) attached to the hub wheel 1 via the equal velocity joint 3.

Also in the case of the embodiment of Fig. 6, the double row tapered roller bearing with vertex of contact angles outside of bearing 2 is designed so as to satisfy a condition that a predetermined form is secured in a state that the raceway tracks of the inner ring 23 and the outer ring 21 are elastically deformed by caulking. The condition can be determined similarly to the embodiments in Figs. 1 through 3.

While there has been described what is at present considered to be preferred embodiments of this invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims

all such modifications as fall within the true spirit and scope of this invention.